MODIS Team Member - Third Quarter Report
Marine Optical Characterizations
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SUMMARY

During this reporting period, the Marine Optical Characterization Experiment (MOCE) team conducted two major field campaigns. In the first expedition (July 8-31), the Marine Optical Buoy (MOBY) system was successfully deployed. This MOBY was the original prototype system which has been completely revise and represents the third fully operational system and is currently collecting data in support of the SeaWiFS which was activated in September. In response to this operational status of SeaWiFS, the team conducted the initial calibration/validation experiment (September 16 - October 5), in which radiometric, biological and atmospheric measurements were made during SeaWiFS overflights. During the beginning of this cruise, the University of Hawaii's RV Kila went on the reef at Lahania and the team had to utilize a 25 ft. dive boat for operations at the mooring site. In spite of this set back data for five out of seven SeaWiFS coincident overpasses were acquired.

VALIDATION/CALIBRATION

The Marine Optics Team provided MOBY and cruise bio-optical data sets for Japan's Ocean Color Temperature Sensor calibration scientists in early August. These data were collected during the test and evaluation deployments of the MOBY systems during October 1996 through February 1997. A total of six stations and nineteen MOBY clear day matchups were sent to NASDA and Goddard Space Flight Center.

FIELD OPERATIONS

M205DOBP (MOBY-L20)

Team members conducted MOBY deployment and bio-optical data collection (M205DOBP), MOBY assembly, and MOBY operations site maintenance in Hawaii, July 12 - 31, 1997 (MOBY-L20). The following personnel participated:

NOAA - Dennis Clark, Ed Fisher, Yuntao Ge, Phil Hovey, Ed King, Larisa Koval, Eric Stengel, Marilyn Yuen, Yi Liu and Yong Sung Kim

MLML -William Broenkow, Mike Feinholz, Stephanie Flora, Daryl Peters, and Mark Yarbrough
CHORS - Dan Sullivan and Chuck Trees

University of Hawaii - Mike Ondrusek
University of Miami - Ken Voss, Joe Ritter, Bob Evans, and Peter Evans

Prior to the deployment and characterization cruise (M205DOBP), radiometric calibrations were performed on MOS205 and SIS. MOBY203 sensors calibrated on 10 - 12 July included upwelled radiance at the top, mid, and bottom arms using the OL420M and GS5000 standard sources, and downwelled irradiance at the surface, top, mid, and bottom arms using the GS5000 calibration source. Calibrations were performed at optimal multiplexer positions as well as one position above and below optimum in case the problems similar to those during MOBY202 deployment are encountered.

Wavelength calibration of MOS205 was checked by scanning line source lamps through the MOBY multiplexer/fiber-optics/collector-head optical path. The profiling radiometer, MOS202, was calibrated on 15 and 29 July for irradiance via the GS5000, radiance via the OL420M, integration time and bin factor via the OL420M, and wavelength via HgA, Ne, Kr, and Xe Oriel lamps. The surface-incident radiometer, SIS101, was calibrated for spectral irradiance on 15 and 29 July via the GS5000 source.

A system calibration was performed on the fiber optic spectrometer system, where both the radiance and irradiance sensors were calibrated. The fiber optic irradiance sensor was calibrated using the new standard lamp F-453 (NIST calibrated) and the radiance sensor was calibrated using the integrating sphere OL420M. The GS5000 was returned to the manufacturer for calibration after the cruise. A program bug was fixed in the diver calibration routines which previously had prevented usage of CCD parameters contained in the hard disk parameter file.

In preparation for the approaching launch of SeaWiFS, the third Marine Optical Buoy (MOBY 203) electrical testing of power system and cellular communications was completed and the final mechanical assembly was conducted and anti-foulant paint was applied. The system was successfully deployed at the Lanai, Hawaii mooring site on July 20, 1997 from the R/V Moana Wave (Fig.1).

Five oceanographic stations were occupied during the eight day cruise M205DOBP (July 19-27, 1997). The team completed the deployment, three buoy diver calibrations, five CTD casts, three MOS profiles, two MOS long-track time-series, and 13 TSM/POC/PON transects. The CTD casts and long-track water pumping yielded 52 TSM and 43 POC/PON filters. During this cruise, 85 HPLC pigment samples were collected for analysis. Of these samples 34 were collected from CTD, primary productivity and VLST casts and 29 replicate samples were collected at 3 meter. For the summed mono- and divinyl chlorophyll a and total accessory pigment concentrations for these replicate samples, the average coefficient of variation was found to be only 4.8% and 5.3%, respectively. The data analysis was completed and the results were delivered to NOAA for quality control. Sun photometer measurements, to derive spectral transmittances, were routinely performed during the cruise.

During the cruise, 53 samples were also collected for pigment analysis using the standard fluorometric technique. The old VisLab fluorometer was shipped from CHORS to Hawaii for the cruise due to a calibration problem that had occurred with the new Turner Designs Fluorometer during the M204 cruise (February 1997). Mike Ondrusek, University of Hawaii, had provided the chlorophyll a standard for M204. A new standard was shipped to Hawaii with the concentration being verified by two spectrophotometers. Both fluorometers were calibrated together and all fluorometric samples were analyzed on both. These results indicated that the problem was indeed associated with the pigment standard provided by University of Hawaii. The difference between the two fluorometers using the new standard was only 9%. Total particulate and dissolved organic material samples were collected and processed during the cruise. The particulate and DOM absorption data have been delivered to NOAA. In addition, we maintained and performed *in-situ* calibrations on the VisLab Spectral Transmissometer during the various survey tows.

In addition to the MOBY deployment, the MOCE team also collected atmospheric data during a transit around Hawaii and in-water data near the Kialuea's Pu'u O'o vent for further examination of volcanic aerosol/hydrosol effects. The Pu'u O'o vent is located on the Big Island of the Hawaiian archipelago, approximately 10 miles east of Kilauea National Park. Lava was flowing through this vent during M205DOBP. Extensive atmospheric optical measurements were conducted along this transit with the University of Miami's sky radiance distribution camera and aureole camera, in conjunction with HHCRM, MD5 radiometer, MOS spectrometer and sky videos (Fig.2). The M205 track line is shown in Fig. 3.

Radiometric data using the Satlantic profiling system were also collected during M205DOBP. Efforts were made to develop software to process the irradiance and radiance data into smoothed K profiles for all channels, and a comparison of several different smoothing techniques was completed. A review of NASA's TM 104566, "Results of the SeaWiFS Data Analysis Round-Robin, July 1997 (DARR-94)," showed that smoothed K values for relatively clear, near-surface waters without cloud contamination contained little vertical structure and were better than 5% for all smoothing programs which were compared. Mueller's integral method for analyzing irradiance and radiance profiles (1991, CHORS Tech. Mem. 007-91) has been adapted at CHORS so that data collected by the Satlantic free-fall radiometer will be processed with its associated 0.30 m in-water irradiance reference cell.

Diver calibrations were obtained after the successful deployment of MOBY203 (Fig. 4). Personnel from MLML completed the diver calibration programs. The programs calculate ratios to analyze changes in collector throughput and detector response over time. Also a diver calibration Web page has been developed which allow the NOAA team: members to easily view the results of the latest diver calibrations.

Postcruise radiometric calibrations were performed on MOS202 and SIS. The MD5 radiometer was post-calibrated for spectral radiance, spectral irradiance, and wavelength. The Hand Held Contrast Reduction Meter (HHCRM) was calibrated

using the OL420M standard source.

M2060B (MOBY-L22)

Team members conducted the initial calibration/validation experiment (M2060B) for SeaWiFS in Hawaii, September 18 - October 10, 1997. The following personnel participated:

NOAA -Dennis Clark, Ed King, Eric Stengel
MLML - Mike Feinholz, Mark Yarbrough, Yong Sung Kim
CHORS - Dan Sullivan, Chuck Trees

The purpose of this trip was to perform in-water optical, atmospheric transmittance and phytoplankton pigment measurements during SeaWiFS overflights and conduct diver calibrations of the MOBY system.

Pre-cruise preparations included calibration of MOS202, SIS101, HHCRM, and MD5 fiber optic radiometer as well as outfitting the R/V Kila for profiling and water sampling operations.

Sun photometer (HHCRM) calibrations were performed on October 1 through a Langley calibration procedure. The validity of using these measurement to calibrate a sun photometer hinges strongly on the assumption that aerosols are uniformly distributed and do not vary throughout the day. Therefore, an area of atmospheric stability with low aerosol loading was chosen to perform the calibration. The site chosen was at the summit of Haleakala 10,000 foot mountain on the Maui (Fig. 5). The Langley plots derived from these measurements are shown in Fig. 6.

SOFTWARE DEVELOPMENT

The at-sea data acquisition system software and hardware update was completed. The system consists of 11 computers that control various instruments. The GPS (Global Positioning System) data (latitude, longitude, speed over ground, heading, and universal time) from two tracking systems are logged by a PowerMac 7300/200 simultaneously. One system is controlled by GPIB (IEEE 488.2 standard) interface, the other by serial connection (RS422). The GPS information is also broadcast through a serial repeater to the other instruments. An electronic flux gate compass controlled with RS232 serial interface also resides on this computer. The compass provides ship heading direction data so that other data can be corrected accordingly, such as wind speed and direction. This computer also serves as a time server. All other computers synchronize their internal clock by pulling time from this computer through ethernet connection.

The meteorological data acquisition system was upgraded to function with new computer systems and previous problems were corrected. The barometer data (air pressure) is logged on a powerBook 1400cs. A simple RS422 interface is used for this purpose. Wind speed and direction (two sensors), air relative humidity and

temperature, as well as water sampling flow rate measured by two on-line flow meters are all recorded on a powerMac 7300/180. The original setup for the wind speed measurements was not accurate. The speed sensor measures wind speed from about 1 m/s to 60 m/s. This range is mapped to 0-1V DC, that is 17 mV for every 1 m/s wind speed change. The two sensors are mounted in front of the ship, cables about 150 fit long were used to connect the sensor to the A/D card. Over this length of cable, the detected noise is around 50 mV, creating an error of about 2 m/s, that is 3 to 4 knots. Also it was found that the A/D (analog to digital conversion) card was set to take differential measurements (voltage difference between two wires), but the physical wire connection was set for single-ended measurements (voltage between signal and fixed ground). Thus all the data measured to that point were wrong and had to be discarded. To fix these problems, a pulse signal was pulled out. The pulse train is generated by three pairs of magnets in the wind sensor. The frequency varies with wind speed. If we measure the frequency, then it is basically noise immune, since frequency counting is similar a to digital signal. The software was also rewritten to accommodate this change. A new calibration procedure was advised to take advantage of the new scheme. Wind direction is measured directly with A/D conversion. Air temperature and relative humidity are measured with two channels on the A/D card. Flow rate is taken through HP frequency counters that are controlled by GPIB.

The sea water temperature and salinity data acquisition was modified to run on a PowerBook 1400cs as well as a software utility called master log. The mater log utility serves as a user input document their operational activities, this information is combined with time and location obtained automatically and recorded in a file. For routine activities such as along-track fluorometric and VLST measurements, profile case, information can be logged in with just a button push in the program. At the end of each cruise, a master log file that recorded all activities is generated.

The fluorometric and VLST system is rather complicated. Three computers are involved. Signals that include fluorescence voltage, depth, GPS time and position, transmittance, filter, mode, temperature are all recorded on a PowerMac 7300/200 computer. These data are packaged and sent to another computer through a serial communication line to another computer called VLST Relay. The relay computer takes the packaged data, unpacks and displays it, and relays the data to yet another computer located in the wet lab. This computer is used for display and data logging. Personnel in this lab use the information to decide when to take a water sample for analysis. They record their calibration data in the program called pigment log, which writes all the chlorophyll calibration information into a file.

The MOCE data processing software was updated and few changes accommodating the data format have been added. Now the software should make the data processing capability near real- time at sea.

The data acquisition software for the fiber optic measurement system was also upgraded. New functions have been added to generate file names according to measurement time automatically. Users have the option to input the file name or take

the default. This modification increases speed and documentation accuracy for these measurements. Also added was the ability to change the headers recorded to the files.

The SGI Challenge computer was upgraded with 10 hard disks and FIDI link. The 10 hard disks have the capacity of 9 GB each disk, for a total of over 90 GB. Together with the original two GB system disk and four GB second disk, the total now is brought up to about 100 GB. We are ready to process SeaWiFS imagery. MODIS processing is being set up too. The new disks are partitioned into several sub-systems. The two GB disk is reserved for system software. The four GB disk reserved for MOBY data, four 9GB-disks are set up as one logical volume for SeaWiFS data, and another four disk cluster is allocated for MODIS data. A nine GB disk is used for application software and user home directory, while the last nine GB disk is partitioned into two sections, one specifically for anonymous ftp and one for additional swap space. Anonymous ftp is set up on this computer to allow data loading over the network. Two DLT drivers are being added to the computer system to read satellite images with tapes. A 4.3 GB magnito-optical disk is also being put on line for quick back up.

Personnel from Moss Landing Marine Laboratories (MLML) completed three solar ephemeris algorithms at various levels of precision to compute solar zenith angles, air mass, sun rise, local noon, etc. These and about ninety other programs have been recently annotated and debugged for general use by the team.

DATA REDUCTION

Development of an algorithm relating *in vito* fluorescence from Moss Landing's CTD system to chlorophyll *a* concentrations is continuing. Data from all MOCE cruises were used in this analysis. The comparison also assisted in identifying outliners in the pigment data base. Upon inspection of the processed fluorescence data, it was found that the output from the logged amplified instrument had been averaged prior to being delogged. This generated errors of up to 15% when the fluorescence values were low, such as in near-surface waters off Hawaii. All CTD profiles will have to be processed again. The output from the fluorometer was also found to be very noisy in surface waters (O-30 meters) and at depth (150-200 meters) when fluorescence is low. This noise was evaluated, and it seems to be caused by the instrument itself.

Work is continuing in further fine-tuning data quality control procedures for pigment data collected during our cruises, MOCE-3 pigment data are currently undergoing these new procedures and will be ready for resubmission to SeaBASS within the next few weeks. Preliminary data quality control measures have been performed on pigment data collected during the M203, M204, and M205 cruises.

The VLST data and chlorophyll a concentrations have been processed for the M204 cruise. Construction of M205 calibration files is underway and as they are completed, M205 data will be processed. Particle size, transmittance, and chlorophyll *a* data sets will be available soon,

Atmospheric transmittance data collected during our cruises were corrected for earth-sun distance. Total optical depths were calculated.

DOCUMENTATION

A web site forthe Marine Optical Team is being developed. The home page resides on a SGI Origin machine. Interested persons can look at it at (URL: http://orbit29i.nesdis.noaa.gov). It introduces the MOBY program and has a picture archive. It also includes downloadable documents such as the MODIS Algorithm Theoretical Basis Document and other historical publications. It will present ocean color algorithms and data samples as well. Links will point visitors to other interesting sites.

CONSOLIDATION OF TEAM RESOURCES

The Marine Optical Buoy (MOBY) facility located at Moss Landing Marine Laboratories (MLML) in Salinas, California, was shut down at the end of August. Operational functions previously based at MLML have been transferred to the MOBY operational site in Honolulu, Hawaii. Marine Optical Characterization Experiment team members Mark Yarbrough, Mike Feinholz, and Yong Sung Kim have relocated from California to Hawaii, and Yi Liu has moved to Camp Springs, MD and joined the Marine Optics Team at NOAA as a contractor.

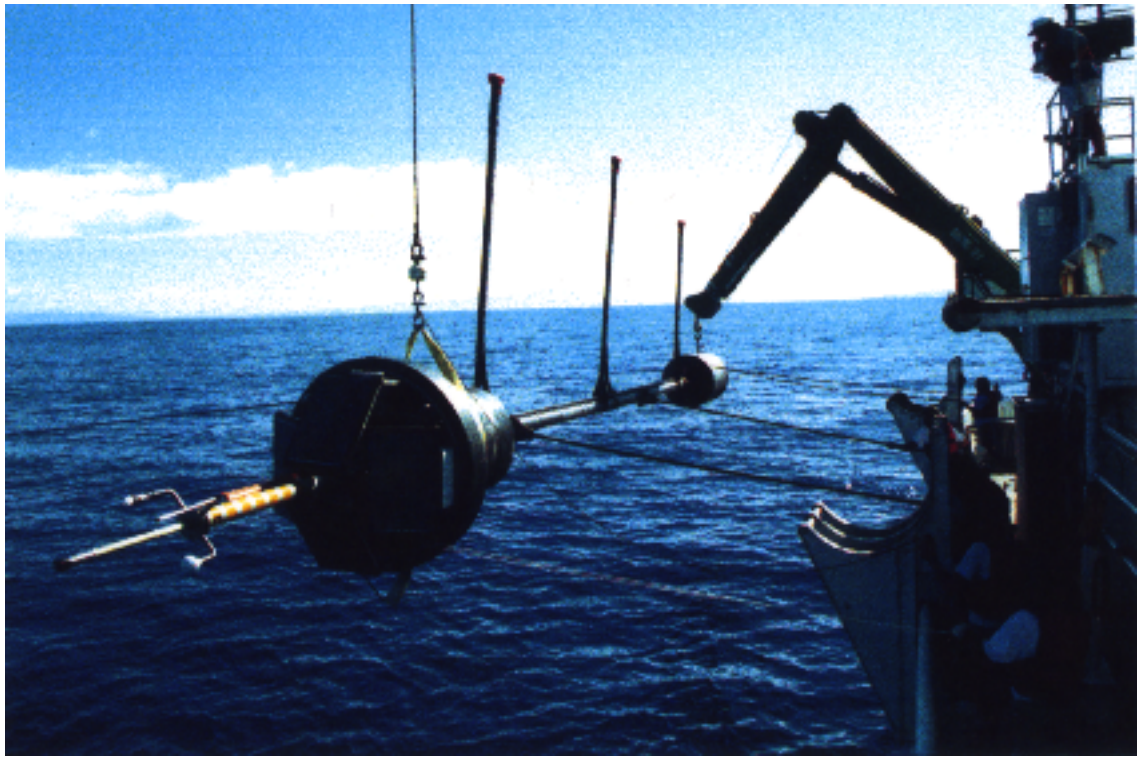


Fig.1 Deployment of MOBY203 on July 20, 1997

Figure 2. Fiber optic spectrograph data acquisition setup during M205DOBP

M205 Track Line

July 25 - 27 1997

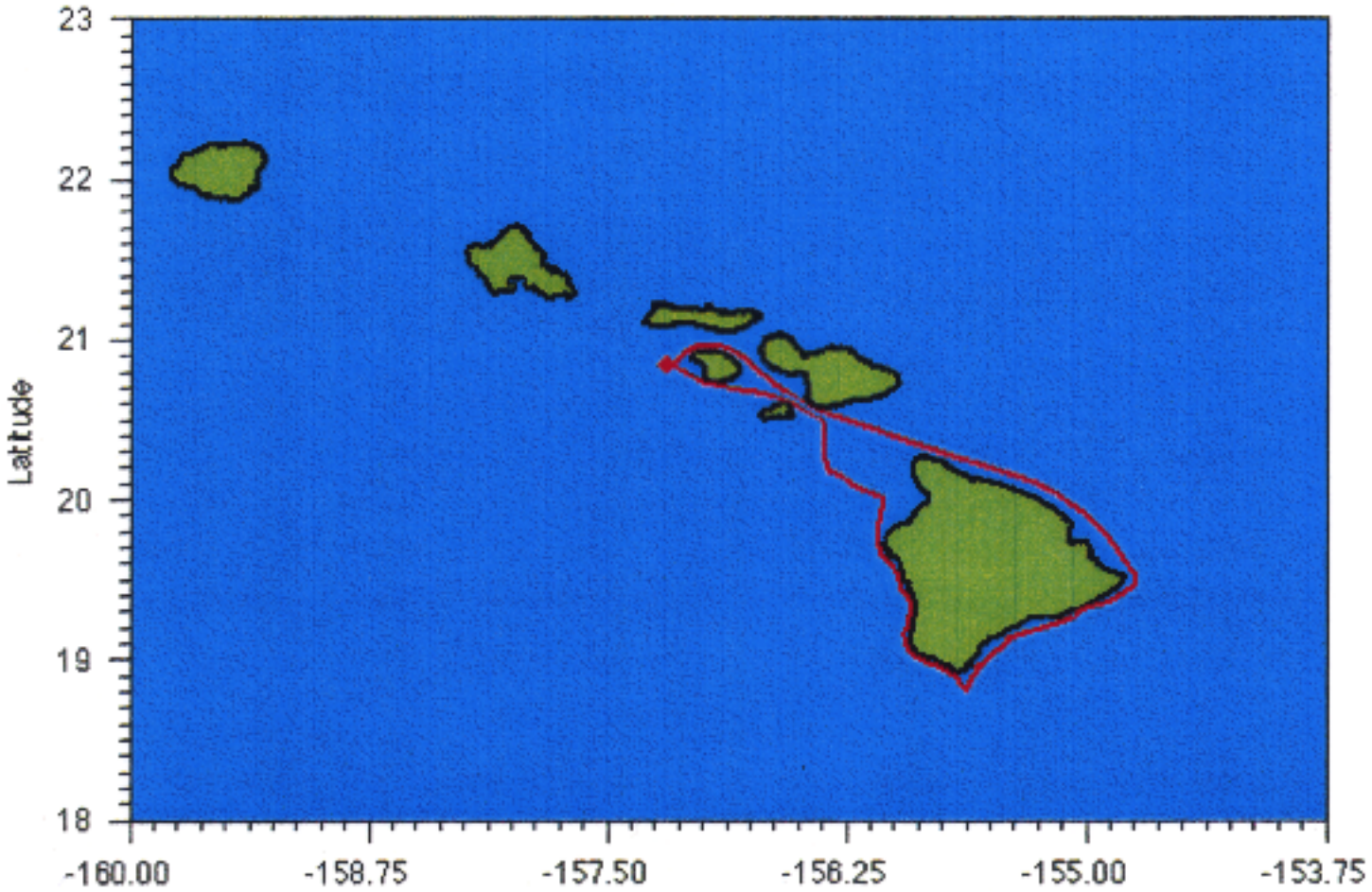


FIGURE 3.

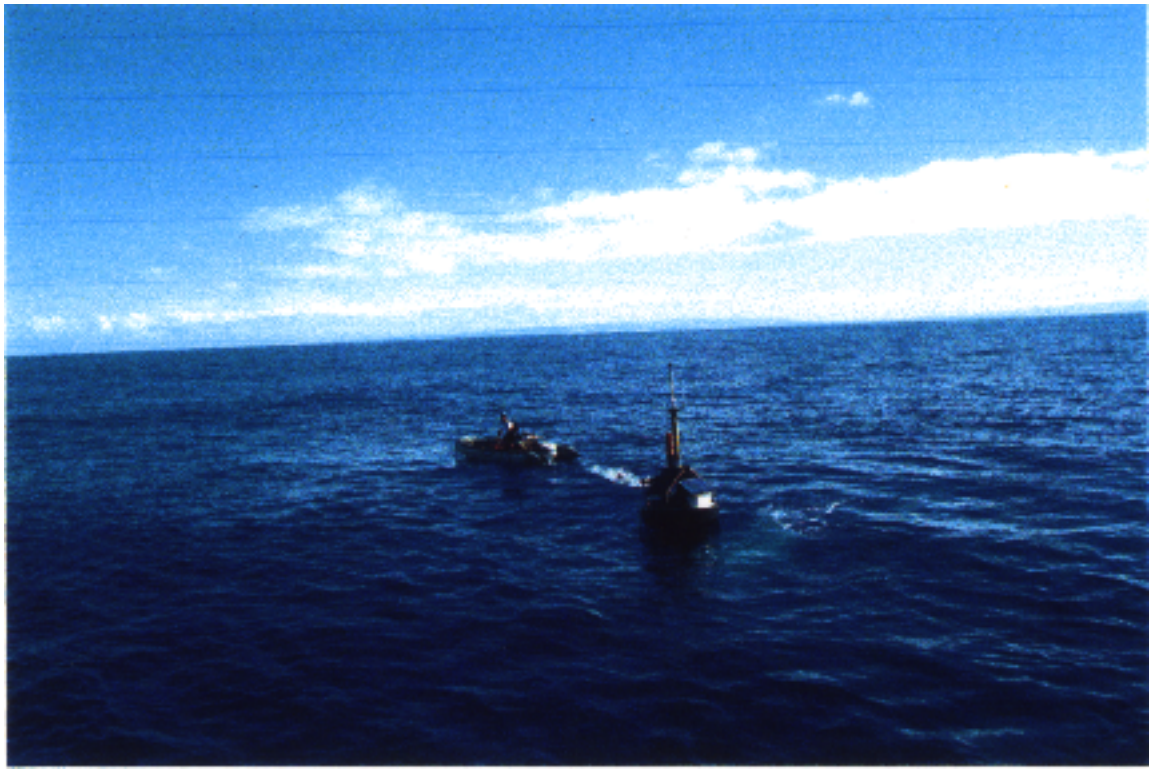
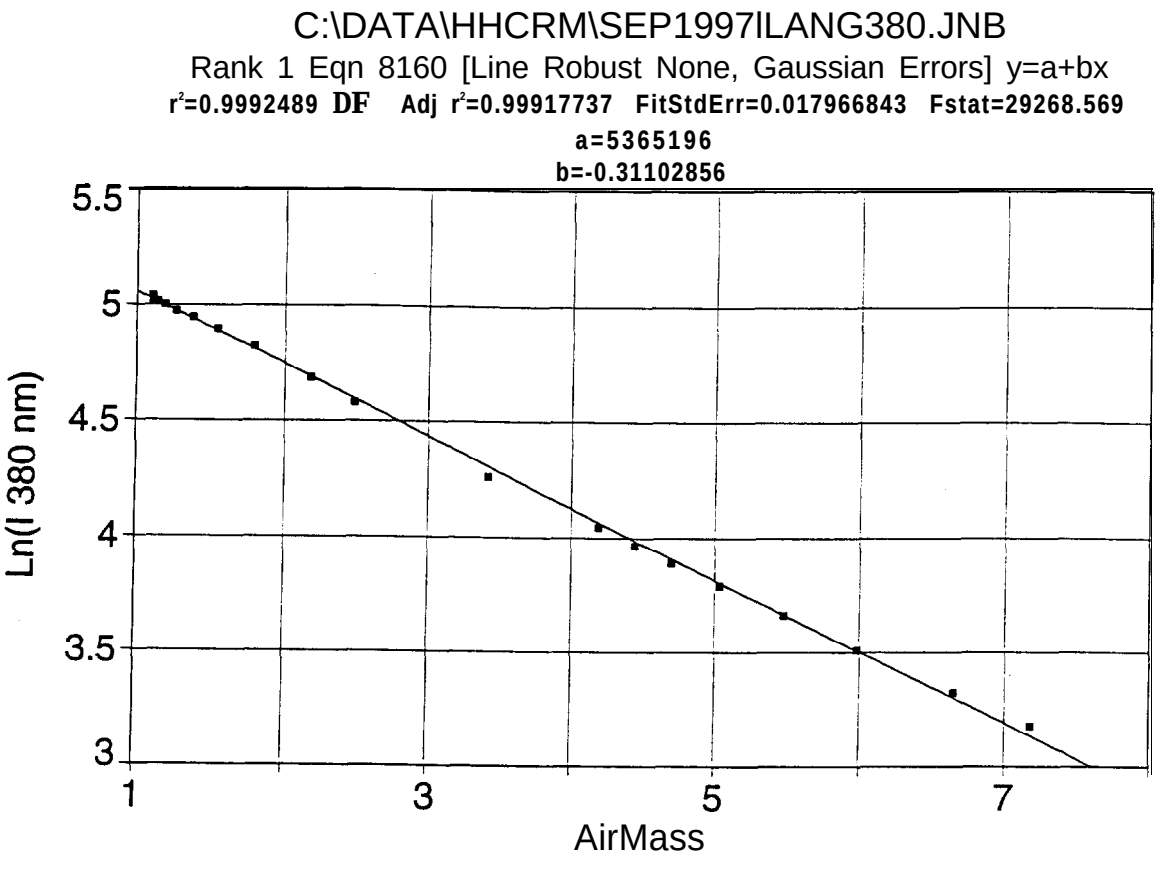


Figure 4. Diver calibration operation during M205DOBP.

Figure 5. Sun photometer HHCRM calibration site.



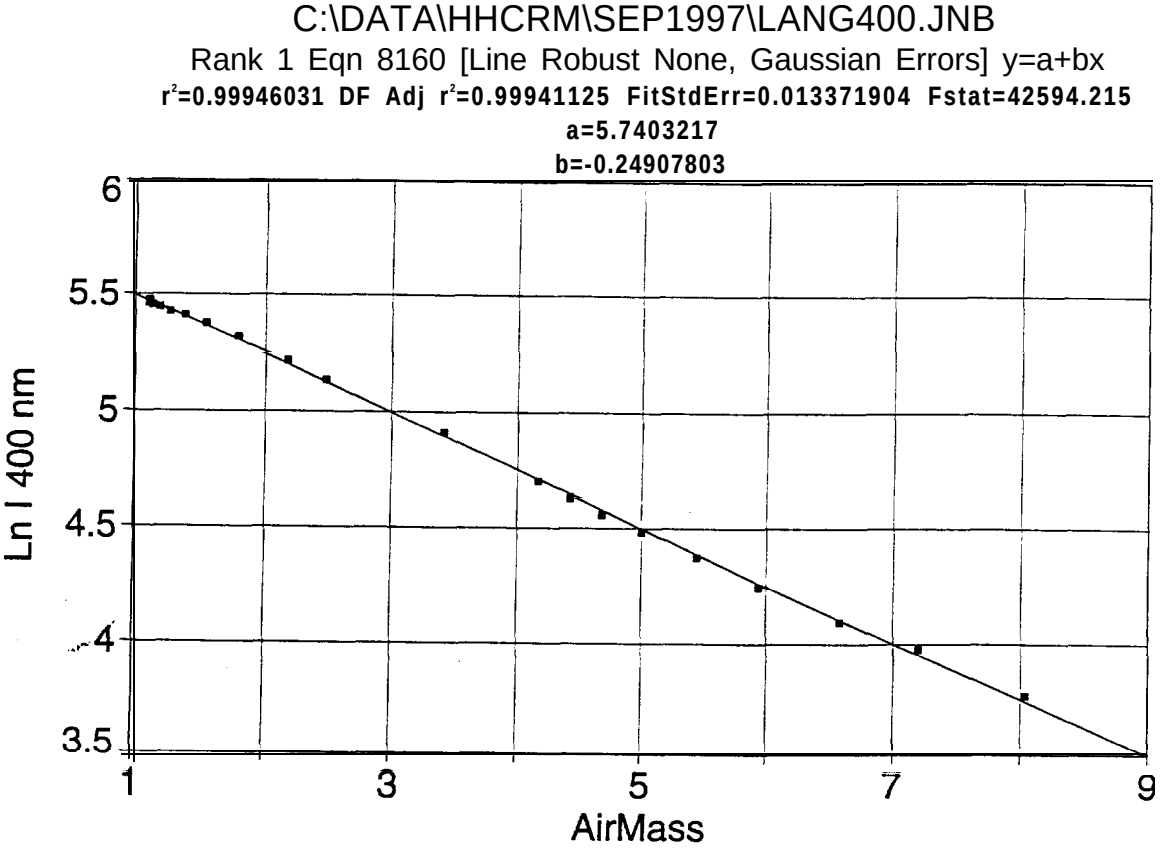


Figure 6. Langley plots obtained during M206OB.